Decentralized ebike-energy-to-grid platform ($\mathcal{DEEP}$): From autonomy to power grid

June 7, 2019

Contents

Abstract

Green power generation, storage and distribution will be composed of millions of small, decentralised power sources of producers and consumers, the prosumers. In such systems, it will be important to connect efficient green power devices to batteries to secure and instantaneous, autonomous green energy transactions across prosumers as energy market conditions change. In this proposal we aim to 1) quantify green power production of pedal turbine generators for bike networks of different sizes, and 2) integrate green power production to a decentralized ebike energy-to-grid platform (DEEP) using blockchain technology. We introduce an integrated smart-testnet mini-grid prototype connecting pedal turbine generators to open-source energy blockchain platforms containing producers and consumers. We outline the bottlenecks, the improvements needed, and a roadmap for the future of coupling efficient turbine generators to decentralized open-source computer and power networks.

Keywords: Green energy. Interconnected networks. Plug-in electric bikes. ebike networks. Smart mini-grid. Computer networks. Power network. Blockchain. Energy harvesting. Micro-energy storage.

Lay summary

—Idea———————
Integrating pedal power turbine generators with dual battery to blockchain energy platforms (i.e., Hyperledger fabric, Tobalaba, Grid+, Powr)erator speed (rpm) vs Output power (W) n

—Transdisciplinarity——————————————————————————-
Data science and modeling: Efficiency curves integrating generator speed (rpm) vs. Output power (W) vs. riding time
(proxy of generator speed) vs. Power (W) bicycle dynamic models, thermodynamics constraints
Engineering and design: oriented to produce and store energy
Computer science: Distributed and blockchain coding, coding VESC open-software
Electric engineer: Design pedal turbine generators, dual battery, inverters and micro-grids
——————————————————————————————

PROS
0. Reduce $C0_2$ across the energy cycle
1. Green energy — sustainable development
2. Local smart grid development
3. Bottom-up: distributed individual-community prosumers
4. Urban bike network development and functional e-mobility networks
5. Research about efficiency and smart metrics by tracking and sharing energy production-consumption data
6. Real time price in the green energy markey by connecting many-to-many battery types-decentralized-green energy platforms
7. Deregulation energy production many countries
8. Frame architecture-design oriented to produce energy

CONS
1. Low efficiency dual battery
2. Low energy recovery
3. Energy production mostly for large kms/day
4. Absence of inverter-energy-to-grid networks in urban landscapes

1 Industry overview

Cities worldwide are under a fast transformation of mobility. Decreasing emissions and congestion are two of the main engines of this rapid transformation and making mobility networks functional while increasing efficiency of e-mobility is one of the first challenges to make it happen. Innovation of e-mobility vehicles is occurring at an unprecedented rates. Many new technologies are being integrated to increase efficiency, autonomy, and connectivity of e-mobility vehicles. This synthesis between rapidly transforming mobility networks and first generation e-mobility vehicles is a first step towards the functionality of mobility networks. The second generation of e-mobility vehicles is yet to be envisioned.

Deregulation of energy production is occurring at many countries and considering mobility networks not only as reducing C02 emisions and congestion but as a decentralized energy production networks is an open issue. Despite a great potential to integrate engines, generators and batteries of e-mobility vehicles to smart-mini-grid using open-source energy platforms, energy production oriented e-mobility devices are at a very incipient stage. Here we introduce two designs for e-mobility, one focused on autonomy and the second one in autonomy, energy production and storage. We provide estimations of efficiency, autonomy and power capacity to discuss the pros and cons of coupling energy-production driven e-mobility vehicles, mobility networks and energy-to-grid networks.

Hundreds of millions of people have attained modern energy access over the last two decades through centralized distribution networks (refs). This means that more people on Earth than ever before are now connected to ever-growing and interconnected power networks. How we power these networks in the next decade will determine much of the impact of humanity on Earth named global warming and biodivesity loss (refs).

First generation e-mobility devices and rapidly expanding mobility networks to reduce emisions and congestion in many cities...

Second generation e-mobility devices coupling functional mobility networks to energy grids to reduce centralization and open energy markets to prosumers... regulation towards decentralized markets? Is it viable to produce energy with electric vehicles like bicycles? Which are the existing numbers and the main scalability issues? How will the new technologies and their integration change the existing numbers?

Green energy storaged devices powering these grids (Solar and wind power, electric vehicles to grid – EV2G), will be an important component to diminish human impact on Earth. Millions of small, decentralised power producers and consumers will have ample choice options. Electric vehicles, solar panels, wind, ebikes...etc will be endpoints interacting with each other in form of microgrids connected to sensors and energy management platforms. In such systems, it will be important to secure green energy production, storage and distribution by verifying instantaneous, decentralized and autonomous transactions across these nodes as green energy demand changes.

However, the transition from the first generation e-mobility devices driven by increasing autonomy and connectance coupled with functional mobility networks to the second generation, e-mobility vehicles to grid is at a very incipient stage. Plug-in electric bikes can potentially be green storage devices. Yet, many questions remain about its power, efficiency and scalability, and how the integration among new technologies (i.e., energy efficiency like backward pedaling..., integrated solar panels) and prototypes designed to produce and store energy will change existing power and efficiency and its relationship to explore autonomy and increase scalability.

Plug-in electric bikes (PEB) as green storage devices will be part of these mobility nerworks. There are, at least three componentsthat need to be integrated to make PEB feasible: 1) ebikes are currently built and marketed as a personal transportation solution, not as a personal plug-in power generator or a energy storage solution. Hubs, motors and frames are not designed with EV2G functionality in mind; 2) Physical infrastructure in the form of a network of dual-energy stations in places such as bicycle parkings and workplaces will be required, and 3) Managing decentralized energy generation and storage accounting for information collection and control of charging/discharging of PEB will be key to distribute green energy from PEB. For example, a platform accounting for individual prosumer behaviour and market signals from the national or international electricity market (refs) (Fig 1).

Here we introduce a blockchain platform connecting battery sensors from a PEB to an energy management software. The blockchain is what makes simultaneous exchange between producers and consumers possible in the first place, and is thus the required link to a certified CO2-free energy world (Box 1). We introduce a case study of a decentralized green energy to blockchain platform currently in testnet phase. Finally we summarize projects building transparent platforms for clean flow of renewable energy from the grid to homes and from homes to the grid (refs).

Ultimately, as dynamic distributed energy markets become mainstream, the owners of decentralized devices can earn an income, not just from the energy they sell but from the network services they provide such as frequency and voltage control, load shifting, load shaping and load sinking.

2 Mobility networks

2.1 First generation e-mobility: autonomy and connectivity

Integration of technologies to increase autonomy and connectivity and reduce emissions and congestion

2.2 Second generation e-mobility: technology integration and scalability

Integration of technologies to reduce energy centralization and increase scalability

2.3 Energy-to-grid platforms

EV2G technology has been in the market since the last decade.

E2GV networks are already functional – give examples. EV examples and existing companies providing dual energy algorithms ...Connecting to the grid – pros/cons costs–distribution in the grid–performance devices–efficiency loss

https://utilitymagazine.com.au/ev2g-imminent-reality-or-electric-fiction/

The key to grid integration of EVbased storage is the aggregation of individual vehicles into a critical mass of total storage, with a combined capacity to palpably impact the grid. Individual storage capacities of single cars for grid integration are currently in the range of only 1 to 95kWh or 0.2 to 19kW output over a five hour discharge of full capacity

However, there are many informational uncertainties and infrastructure voids which would need to be overcome to make EV2G feasible. Physical infrastructure in the form of a network of chargers in places such as car parks and workplaces will be required. In addition to physical infrastructure, EV2G systems will require significant informational infrastructure to operate. This will require the construction of a deep information layer, including data on individual EVs, their parking status, storage capability, power flows, state of charge, and the preferences and constraints of car owners and these are just some of the datasets required to effectively realise EV2G

Decentralizing energy production from individuals to the blockchain technology – examples of companies

2.4 Regulation

Regulations that might affect mobility networks

2.4.1 Deregulating energy markets

Deregulated energy markets

2.4.2 Regulating EV limits but energy production?

regulation EV – speed limits but energy production?

Plug-in electric bikes (PEB) belongs to a broader class of EV2G but with much more speed limit (max energy per capita USA law is < 20 mph unassisted and < 750 watt motor = bicycle). The most influential definition which distinguishes which e-bikes are pedelecs and which are not, comes from the EU directive (EN15194 standard) for motor vehicles, a bicycle is considered a pedelec if the pedal-assist, i.e. the motorised assistance that only engages when the rider is pedalling, cuts out once 25 km/h is reached, and when the motor produces maximum continuous rated power of not more than 250 watts (n.b. the motor can produce more power for short periods, such as when the rider is struggling to get up a steep hill).

An e-bike conforming to these conditions is considered to be a pedelec in the EU and is legally classed as a bicycle. The EN15194 standard is valid across the whole of the EU and has also been adopted by some non-EU European nations and also some jurisdictions outside of Europe (such as the state of Victoria in Australia).

Pedelecs are much like conventional bicycles in use and function the electric motor only provides assistance, most notably when the rider would otherwise struggle against a headwind or be going uphill. Pedelecs are therefore especially useful for people living in hilly areas where riding a bike would prove too strenuous for many to consider taking up cycling as a daily means of transport. They are also useful when it would be helpful for the riders who more generally need some assistance, e.g. for elderly people

In summary pedelecs have pedal-assist only, motor assists only up to a decent but not excessive speed (usually 25 km/h), motor power up to 250 watts.

3 EV: from autonomy to production and storage design

3.1 Estimations autonomy

Data available about the time evolution of autonomy – is it increasing?

3.2 Estimations per capita energy production

Estimations existing er capita energy production Estimations future energy production integrating efficiency and new engines

Max watts per hour for a 250 watts motor Battery performance and efficiency: battery types

(Li-ion or Li-air batteries and plug-in devices contain pros/cons that need to be taken into account to accurarely estimate efficiency and per-capita energy production. See Fig 1: historical efficiency of batteries and plug in devices);

scalability

3.3 EV designed for maximum autonomy

Carry on the plan
Quantitative assessment
Kw consumed to Kw produced (for example Tesla vs velo)
Ratio Kwcons$/Kw$pro$vsrentability?$
$Evolutionefficiency - cycles - sizebatt$
$Km/hvs.Kwvs.efficiency$
$Kwvs.efficiency(market)$
$Solution$
$Gobackwards$
$Isitcorrect?Reproducible?$
$Applytootherproblems?Data?$

3.4 EV designed for energy production and storage

Carry on the plan
Quantitative assessment
Kw consumed to produced Kw (for example Tesla vs velo)
Ratio Kwcons$/Kw$pro$vsrentability?$
$Evolutionefficiency - cycles - sizebatt$
$Km/hvs.Kwvs.efficiency$
$Kwvs.efficiencyvs.(market)$
$Solution$
$Gobackwards$
$Isitcorrect?Reproducible?$
$Applytootherproblems?Data?$

4 Testnet: Decentralized ebike-energy-to-grid platform (DEEP)

Universal-battery app Hub-battery specific app

Decentralized energy markets connect homes and electric vehicles with software that automatically sells and buys power to and from the grid on the basis of real-time price signals. Tracking of renewable-energy certificates is one of dozens of potential applications of blockchain technology that could solve data management challenges in the electricity sector. Blockchain allows secure verifiability and transparency of the energy transactions using small-scale batteries. This ensures a simple connection between suppliers of locally distributed flexible energy producers and consumers demanding power locally or regionally from the grid.

Many platforms currently allow for setting up a blockchain framework to track green energy in the power grid. We will implement two testnets, one using the Hyperledger Fabric, one of the Hyperledger projects hosted by The Linux Foundation, and a second one using Tobalaba, a testnet hosted by the Energy Web Foundation (http://energyweb.org/network/). Here we introduce a testnet to plug-in a small number of ebikes to the grid accounting for an ID-renewable-energy certificate, spatial location of the transaction () and metrics to characterize the stability of the power grid. The steps are the following:

1. Connect hub motor and batteries to an open-software and interface

Examples http://vedder.se/2015/01/vesc-open-source-esc/ https://www.kickstarter.com/projects/800872710/os-ebike-open-source-electric-bicycle-design-you-c/description

A VESC is at the heart of the bike and handles the BLDC (brushless direct current) motor control, receives input from the throttle or pedal sensors, and outputs data to the display to show speed, distance, battery statistics, or anything else you'd like to view while riding.Â

2. Plugin hub battery using VESC to the grid (plugin energy converted required). Check grid features. 3. Login deep app to connect to the bluetooth ready battery. Go to renewable-energy certificate (REC) to generate the ID and kw of energy to upload 4. Connect to P2P trading, tobalaba or Hyperledger fabric 5. You can choose between A. buyers and kw price or B. upload energy to the grid using the ID 6. Link the ID to your account and transfers will be made in "real" time

App connecting hub battery to tobalaba grid+ or ibm - open-source energy blockchain platform

Own crypto https://www.ethereum.org/token

Grid+ https://blog.gridplus.io/gridx-the-future-of-energy-markets-da104c285363?gi=3e04edc41244

Grid singularity http://gridsingularity.com//0/1

Tobalaba http://energyweb.org/network/

Power ledger

LO3

arcc batripower neomou

5 Roadmap

https://blockhive.ee/ilp

-
-

6 Boxes

Box 1: What can add the blockchain technology to the decentralization of energy?

Box 2: Flowchart steps 1-6: 1. Battery hub and converter; 2. connect app to battery hub; 3. Generate REC and ID; 4. Connect P2P trading; 5. Select energy type, quantity and how to sell, and 6. Receive payments in crypto or currency

7 Figures

Fig. 2. Efficiency per capita energy production: kms-hub efficiency power-electricity plot + plugin cost :

8 FAQ

How much energy can an ebike produce per time?
How much energy can an ebike network produce per time?
Which are the main scalability constraints?
How much energy can be sent back to the grid accounting for plugin losses, efficiency and regulations?

Figure 1: Grid-interactive ebike system

9 Acknowledgements

10 References